SOFT TRANSLATING CONTACT LENS FOR PRESBYOPIA

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to optics and, more specifically, to soft contact lenses.

2. Description of the Prior Art

Contact lenses are widely used for many different types of vision deficiencies. These include defects such as near-sightedness and far-sightedness (myopia and hypermetropia, respectively), and defects in near range vision usually associated with aging (presbyopia). Presbyopia occurs as a person ages when the lens of eye begins to crystalize and lose its elasticity, eventually resulting in the eye losing the ability to focus on nearby objects.

Some presbyopic persons have both near vision and far vision defects, requiring bifocal lenses to properly correct their vision. Many people prefer wearing contact lenses to correct their vision rather than bifocal eye glasses.

A typical single vision contact lens has a focus, which is the point on which parallel rays of light focus when the lens is placed perpendicular to the parallel rays, and an optical axis, which is an imaginary line drawn from the focus to the center of the lens. A posterior surface fits against the cornea and an opposite anterior surface has a vision surface that focuses light to correct the eye's vision. In the case of a typical spherical lens, the vision surface has a single radius of curvature that is the distance from any point on the vision surface to a point on the optical axis referred to as the center of curvature. A bifocal lens has at least two vision surfaces on the anterior surface of the lens: a distance vision surface, for gazing at far off objects, and

a near vision surface, for gazing at close objects (*e.g.*, while reading).

Effective use of a bifocal contact lens requires translation of the eye between vision surfaces when the eye changes from gazing at an object at a distance to gazing at a nearby object. In such a situation, the pupil must move from being subtended by the distance vision surface to being subtended by the near vision surface.

Contact lenses generally are either hard lenses or soft lenses. Hard lenses tend to be less comfortable than soft lenses and, therefore, are usually worn for shorter periods of time.

While there are many designs for hard bifocal contact lenses, soft contact lenses have difficulty translating across the surface of the eye when the visual direction of the eye changes from horizontal gaze distance vision to down gaze near vision. This is due to the ability of a soft contact lens to conform closely to the shape of the cornea. For this reason, soft translating bifocal contact lenses are uncommon. Thus, users who desire bifocal contact lenses are usually limited to using the more uncomfortable hard lenses, while those who wish to wear soft contact lenses are usually limited to wearing monofocal lenses.

Therefore, there is a need for a soft bifocal contact lens that supports translation across the surface of the eye when the eye changes position from distance vision to near vision.

SUMMARY OF THE INVENTION

The disadvantages of the prior art are overcome by the present invention which, in one aspect, is a contact lens having top, a bottom, a rotational axis, an inner surface and an opposite outer surface, the outer surface including a plurality of zones. The plurality of zones include an optical zone, a ridge zone, a transition zone and a bevel zone. The optical zone has a lower edge, and includes a distance vision zone and a near vision zone.

The distance vision zone has a first radius of curvature that provides distance vision correction. The distance vision zone also has a first area that is sufficient to overlay a substantial portion of a pupil of a user and is disposed in a first position within the optical zone so that the user's pupil is substantially subtended by the distance vision zone when the user is gazing at a substantially horizontal point.

The near vision zone is substantially concentric with the rotational axis and extends radially outward from the distance vision zone. The near vision zone has a second radius of curvature that provides near vision correction and has a second area that is sufficient to overlay a substantial portion of a pupil of a user. The near vision zone is disposed in a second position within the optical zone so that the user's pupil is substantially subtended by the near vision zone when the user is gazing at a near vision point below the substantially horizontal point.

The ridge zone has an upper edge and a lower edge and is disposed below the optical zone. The ridge zone includes a latitudinal ridge portion that extends outwardly from the outer surface to enable engagement with a lower eyelid of a user and thereby provide vertical translation support for the contact lens when being worn by the user. The transition zone extends from the lower edge of the optical zone to the upper edge of the ridge zone and provides a smooth transition from the ridge zone to the optical zone.

In another aspect, the invention is a method of producing a master cast used in making a contact lens mold. A blank, having an outer surface, is rotated about a first

rotational axis and at least one first surface is cut onto the outer surface of the blank. The blank is also rotated about a plurality of secondary rotational axes, wherein each secondary rotational axis is different from the first rotational axis. A portion of a ridge-off surface is cut from the outer surface of the blank while it is rotating at each secondary rotational axis. Thus, a ridge-off surface is formed once the blank has been rotated about each of the plurality of secondary rotational axes.

These and other aspects of the invention will become apparent from the following description of the preferred embodiments taken in conjunction with the following drawings. As would be obvious to one skilled in the art, many variations and modifications of the invention may be effected without departing from the spirit and scope of the novel concepts of the disclosure.

BRIEF DESCRIPTION OF THE FIGURES OF THE DRAWINGS

FIG. 1A is a front elevational view of one embodiment of the invention.

FIG. 1B is a cross-sectional view, exaggerated along the horizontal axis, of the embodiment shown in FIG. 1A, taken along line 1B-1B.

FIG. 1C is a detail view of a portion of FIG. 1B.

FIG. 2A is a side elevational view of an uncut master cast blank mounted on a spindle.

FIG. 2B is a is a side elevational view of the master cast blank of FIG. 2A after a first surface has been cut from the master cast blank.

FIG. 2C is a perspective view of a spacer used to offset the axis of rotation of the spindle and master cast blank.

FIG. 2D is a side elevational view of the master cast blank and the spindle with the spacer of FIG. 2C applied thereto after a ridge-off surface has been cut from the master cast blank.

FIG. 3A is a front elevational view of a master cast blank after a first ridge-off zone has been cut.

FIG. 3B is a front elevational view of a master cast blank after a second ridge-off zone has been cut.

FIG. 3C is a front elevational view of a master cast blank after a third ridge-off zone has been cut.

FIG. 3D is a front elevational view of a master cast blank after a fourth ridge-off zone has been cut.

FIG. 3E is a front elevational view of a master cast blank after a fifth ridge-off zone has been cut.

FIG. 4A is a front elevational view of an optical zone having horizontal distance vision and near vision zones.

FIG. 4B is a front elevational view of an optical zone having a non-circular distance vision zone.

FIG. 4C is a front elevational view of an optical zone having circular distance vision and near vision zones.

DETAILED DESCRIPTION OF THE INVENTION

A preferred embodiment of the invention is now described in detail. Referring to the drawings, like numbers indicate like parts throughout the views. As used in the description herein and throughout the claims, the following terms take the meanings explicitly associated herein, unless the context clearly dictates otherwise: the meaning of "a," "an," and "the" includes plural reference, the meaning of "in" includes "in" and "on."

As shown in FIGS.. 1A-1C, one embodiment of the invention is a contact lens **100** having top **108**, a bottom **109**, a rotational axis **102**, an inner surface **104** and an opposite outer surface **106**. The outer surface **106** includes an optical zone **110**, a transition zone **140**, a ridge zone **150**, a ridge-off zone **160** and a bevel zone **170**. The optical zone **110** has a lower edge **114** and includes a distance vision zone **120** and a near vision zone **130**.

The distance vision zone **120** has a first radius of curvature that provides distance vision correction for the user. The area of the distance vision zone **120** is sufficient to overlay a substantial portion of a pupil **106a** of a user. The distance vision zone **120** is disposed so that the user's pupil **106a** is substantially subtended by the distance vision zone **120** when the user is gazing at a substantially horizontal point. Typically, the distance vision zone **120** will be offset from the rotational axis **102**. This is so that the pupil **106** will be substantially subtended by the near vision zone **130** when the eye **107** is looking down (*e.g.*, when the eye **107** is engaged in reading). The distance **a** from the center **102** to the bottom of the distance vision zone **120** should be the minimum distance that allows the pupil **106a** to be substantially subtended by the distance vision zone **120** when gazing at the horizon. This will may result in the distance vision zone **120** having an oval shape.

The near vision zone **130** is substantially concentric with the rotational axis **102** and extends radially outward from the distance vision zone **120**. The near vision zone **130** has a second radius of curvature that provides near vision correction for the user. The area of the near vision zone **130** is sufficient to overlay a substantial portion

of the pupil **106b**. The near vision zone **130** is disposed so that the user's pupil **106b** is substantially subtended by the near vision zone **130** when the user is gazing at a near vision point below the substantially horizontal point (*e.g.*, while reading). Both the distance vision zone **120** and near vision zone **130** could be place either on the inner surface **104** or the outer surface **106** of the lens **100**.

The ridge zone **150** provides vertical translation support for the lens **100**. The ridge zone **150** has an upper edge **156**, a lower edge **158**, a first side edge **152** and a second side edge **154**. The ridge zone **150** is disposed below the optical zone **110**. A latitudinal ridge portion **159** extends outwardly from the outer surface **106** to enable engagement with the user's lower eyelid **105**. Thus, when the eye **107** moves in a downward direction, the ridge portion **159** engages the lower eyelid **105** and supports the lens **100**, thereby allowing translation of the lens **100** across the surface of the eye **107**.

The transition zone **140** provides a smooth transition from the ridge zone **150** to the optical zone **110**. The transition zone **140** extends from the lower edge **114** of the optical zone **110** to the upper edge of the ridge zone **156**.

Typically, to provide corneal coverage, the lens **100** also includes a ridge-off zone **160**, which extends outwardly from the top edge **112** of the optical zone **110**, the first side edge **152** of the ridge zone **150** and the second side edge **154** of the ridge zone **150**. The ridge-off zone **160** should have sufficient area so that the ridge-off zone **150**, the optical zone **110**, the ridge zone **150** and the transition zone **140** cover substantially all of a user's cornea. The ridge-off zone **160** adds lens rotational stability and improves the comfort of the lens **100**. For added comfort, the lens **100** may also include a bevel zone **170**, extending radially outward from the ridge-off zone **160** and the lower edge **158** of the ridge zone **150**, that tapers to a narrow end **172**.

A lens **100** according to the invention typically would be made from a soft contact lens material, such as a silicon hydro-gel or HEMA. Although, it will be understood that any lens described above comprising any soft contact lens material would fall within the scope of the invention.

A contact lens according to the invention could be constructed using a conventional contact lens molding process. With such a process, a mold is made from a master cast of the exterior surface and a master cast of the interior surface. The master cast of the exterior surface could be formed on a conventional computer-controlled cutter in conjunction with a lathe, of the type conventionally used in making master casts of contact lenses.

As shown in FIG. 2A, a master cast blank **200** is mounted on a spindle **220** and is rotated around a rotational axis **202** in a preselected direction **A**. Initially, as shown in FIG. 2B, at least one first surface **210** is cut onto the outer surface **206** of the blank **200**. The first surface **210** would include the optical zone, the transition zone, the ridge zone **250** and the bevel zone. At this point, the ridge zone **250** would extend circularly about the outer surface of the blank **200**. The various vision surfaces would be cut into the blank **200** by carefully controlling the depth of the cutting instrument (as with a conventional computer control mechanism) as the blank **200** rotates.

Depending on the precision of the cutting instrument, cutting the ridge-off zone may require offsetting the axis of rotation of the blank **200**. This is done by adding a spacer **230**, as shown in FIG. 2C, to the spindle **220**. The spacer **230** is essentially an elongated sleeve having an opening **232** passing longitudinally therethrough. The opening **232** is complementary in shape to the spindle **220** so as to allow the spindle **220** to fit within the spacer **230**. The spacer **230** has a secondary rotational axis **204** so that when the spindle **220** is inserted in the spacer **230**, the blank **200** rotates about the secondary rotational axis **204**, which is offset from the rotational axis **202** of the spindle **220**. By changing the orientation of the spindle **220** within the spacer **230**, the blank will have a plurality of secondary offset rotational

axes. Each different offset rotational axis causes the blank **200** to rotate with a different eccentric orbit so that a different portion of the outermost edge of the blank **400** is furthest outward during the orbit. Thus, when the spindle **220** is placed within the spacer **230** as shown in FIG. 2D, the portion **260** of the blank **200** opposite the rotational axis **202** of the spindle **220** will orbit farthest from the secondary offset rotational axis **204**. While rotating in this fashion, a crescent-shaped portion **260** may be cut into the blank **200** removing undesired material **262** from the blank, thus forming a portion of the ridge-off zone.

As is shown in FIGS. 3A-3E, the complete ridge-off zone **360** is formed by rotating the blank **300** about a plurality of secondary axes **304a-e** (each being offset from the rotational axis **302** of the blank) and cutting a plurality of crescent-shaped portions **362a-e** from the blank **300**. Generally, cutting five crescent-shaped portions **362** will result in the formation of the ridge-off zone **360**, although cutting more crescent-shaped portions **362**, using a corresponding number of offset axes **304** of rotation, will result in a smoother ridge-off zone **360**.

As will be readily appreciated by those of skill in the art, many different shapes of vision zones are possible with the present invention. Three illustrative examples of such shapes **410a-c** are shown in FIGS. 4A-4C.

The above described embodiments are given as illustrative examples only. It will be readily appreciated that many deviations may be made from the specific embodiments disclosed in this specification without departing from the invention. Accordingly, the scope of the invention is to be determined by the claims below rather than being limited to the specifically described embodiments above.